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RESIDENTIAL ENERGY DEMAND AND ENERGY-EFFICIENCY OF THE EU MEMBER STATES: A STOCHASTIC FRONTIER APPROACH

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Overview

In 2010, the EU adopted a new energy strategy Energy 2020 – a strategy for competitive, sustainable and secure energy, where energy-efficiency is listed among the five priorities. Member states are, in comparison with projected trends, expected to achieve 20% energy savings by 2020. However, the latest report by European Commission (2011) suggests that with the present policies the EU will achieve only half of the 20 % target in 2020. This is claimed not to be because of the lack of economic potential but because of market and regulatory failures. In order to close this gap, a new directive on energy efficiency has been proposed.

Since the residential sector is identified as being one of the areas with the greatest potential for energy savings (Directive 2006/32/EC), this paper employs stochastic frontier analysis (SFA) to estimate a 'frontier' residential energy demand function using panel data for 27 EU member states over the period 1996 to 2009. Following the approach proposed by Filippini and Hunt (2010, 2011) and Evans, Filippini and Hunt (2011), an econometric energy demand model is used to estimate the inefficiency of each member state, which gives an indication of the each state's potential for energy efficiency improvement. As opposed to the more conventional indicator of energy intensity (i.e., energy demand to GDP ratio), this measure of energy efficiency controls for a range of economic and other factors and is therefore viewed as a more suitable approach to measure energy efficiency.

Methods

The stochastic frontier approach is employed to estimate the following log-log 'frontier' energy demand function:

$$ln\,ARED_{it} = b_0 + b_{PE}\,ln\,PE_{it} + b_{YPC}\,ln\,YPC_{it} + b_{HS}\,ln\,HS_{it} + b_{HDD}\,ln\,HDD_{it} + b_{HOT}\,HOT_i + b_t D_t + v_{it} + u_{it}, \quad (1)$$

where $ARED_{it}$ is the average residential energy consumption measured in million tonnes of oil equivalent (Mtoe) per household, YPC_{it} is GDP per capita in EUR (in 2000 prices), PE_{it} is the real energy price (2005=100), HS_{it} is the average household size, and HDD_{it} is the heating degree days; all for member state *i* in year *t*. Furthermore, HOT_i denotes the hot climate dummy and D_t is a series of time dummy variables. The error term in (1) is composed of two independent parts. The first part, v_{it}, is a symmetric disturbance capturing the effect of noise and is assumed to be normally distributed. The second part, u_{it}, is interpreted as an indicator of the inefficient use of energy. It is a one-sided non-negative time-varying random disturbance term, assumed to follow a half-normal distribution. Moreover, since energy consumption and the regressors are in logarithms the coefficients are directly interpretable as demand elasticities.

The study is based on an unbalanced panel data set for a sample of 27 EU member states ($i = 1, \ldots, 27$) over the period 1996 to 2009 ($t = 1, \ldots, 14$). The data set is based on information taken from the Odyssee data base and Eurostat.

From the econometric point of view, equation (1) is estimated using the Pooled method proposed by Aigner et al., (1977), and the True Random Effects method (TRE) and the Random Parameters method (RPM) for panel data proposed by Greene (2005a and 2005b). The latter two methods allow controlling for country-specific time-invariant heterogeneity, while the RPM method additionally allows for parameter estimates to differ among member states. In particular, the interest of the study lies in obtaining time- and country-specific technical change estimates.

Preliminary Results

The estimated coefficients have the expected signs and are generally statistically significant in all models. The estimated own price elasticity in the Pooled model of -0.06 is not found to be significant, whereas in the TRE model statistically significant estimate of price elasticity of about -0.09 is obtained. Similarly, the two RPM models result in significant estimates of price elasticities of -0.08 and -0.11, respectively. The estimated income elasticity is significant in all models; in the pooled model it is about 0.32, while in the TRE model and the two RPM models varies between 0.18 and 0.23. The two climate variables appear to have a consistent and significant influence on a residential demand in all models; heating degree days are associated with higher residential energy demand, while in the case of hot climate negative relationship is established.

The time dummies represent three-year periods with the exception of the last period which, due to unavailable data for 2010, consists of only two years. The estimated coefficients indicate the presence of technical change, which is, compared to the first period, highly significant for the last two periods, whereas for the second and the third period significance is not established in all models. This may be viewed as evidence on effectiveness of the EU energy policy related to promotion of energy-efficiency in the recent years. Nevertheless, the two RPM models reveal large degree of variation in technical change among the EU member states, indicating that there is still considerable room for improvement. A fair degree of variation among the EU member states is also established in energy efficiency estimates. The obtained average energy efficiency using the Pooled model is 84%, while the TRE model and the two RPM models result in energy efficiency around 93%. The new EU members are on average found to perform slightly worse than the old EU member states. It should also be noted that the inefficiency estimates of the TRE and RPM models may be underestimated as they do not include the persistent inefficiencies that might remain constant over time and that are captured by the individual effects.

Conclusions

This research combines the approaches taken in energy demand modelling and frontier analysis in order to estimate the 'underlying energy efficiency' for each EU member state. The estimates for the energy efficiency and technical change confirm that the EU residential sector indeed holds a relatively high potential for energy savings. Despite the common objective to decrease energy consumption, considerable variation in energy efficiency and technical change between the EU member states is established, implying that not all countries have been successful in decreasing energy consumption. To further evaluate the effectiveness of energy-efficient measures undertaken in the EU residential sector, additional set of variables may be introduced in the model. Identified best practice countries could serve as a benchmark for implementing policy measures that may further enhance energy efficiency in the EU.

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